Report On

Musk Deer Count in Sagarmatha National Park and its Buffer Zone

Submitted To

Sagarmatha National Park Office
Namche Bazaar, Solukhumbu, Nepal

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VAT No. 603521612
Regd. No. 138181/072/73

Asian Center for Development Pvt. Ltd.
Budhanilakantha -4, Kathmandu

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Rameshwar Bhattarai

Managing Director

Asian Center for Development Pvt. Ltd.

Budhanilakantha-4, Kathmandu, Nepal

Abbreviations used

ACA :	Annapurna Conservation Area
BZ	Buffer Zone
CAMC :	Conservation Area Management Committee
CFUG	Community Forest Users Group
CITES :	Convention on International Trade of Endangered Species of Wild Flora and Fauna
cm :	centimeters
DNPWC:	Department of National Park and Wildlife Conservation
GoN:	Government of Nepal
GPS :	Global Positioning System
ha :	Hectare
HMG/N :	His Majesty's Government of Nepal
IOF :	Institute of Forestry
IUCN :	International Union for Conservation of Nature and Natural
IVI :	Importance Value Index
Km^2 :	Square kilometer
m :	meters
NTFPs :	Non-Timber Forest Products
OIC :	Office-in-Charge
pers. comm.:	personal communication
	Resources
SNP	Sagarmatha National Park
UCO :	Unite Conservation Office

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Executive summary

Sagarmatha National Park (SNP), established in 1976 is one of the pioneer protected areas of Nepal. The park was inscribed as world heritage property in 1979 because of its superlative and exceptional natural beauty, which is embedded in the vivid mountains, glaciers, deep valleys and majestic peaks including the world's highest peak, Mt. Everest. The park is a home to some of the endangered wildlife species including snow leopard, musk deer and red panda.

Musk deer are distributed at elevations between 3000-4200 m in SNP. However, they can be sometimes observed in lower parts at an altitude of 2800 m (Jorsalle). They are distributed from Tasinga, Chhuwa, Lausasa, Seluwa, Kyanjuma, Phungithaga, Thulo Odar up to Shyangboche (3,720 m); from Debuche, Omaka, Milunga, Yaranga up to Pangboche (3,930 m) on the way to the Island Peak; from Mongla (3,973 m), Phortse Thanga, Phortse Pakha, Phortse up to Dole (4,200 m) on the way to Gokyo and from Furte, Pare up to Thamo (3,493 m) on the way to Gomo or Mokyo. Musk deer is commonly found in SNP between 2,500-4,000 m where the area is covered by Birch (*Betula utilis*), Fir (*Abies spp.)* and Rhododendron (*Rhododendron spp.).* It is also recorded from *Pinus wallichiana* and *Arundenaria* forests, and sometimes it comes out to open grasslands and potato fields. Musk deer is mostly found in Tengboche, Tasinga, Phortse, Pangboche, Dole, Kyanjuma and Syangboche areas. Approximately 49 km square area of the SNP is considered as suitable habitat for musk deer.

The main objective of the current study is to update the population status of Musk deer in Sagarmatha National Park and its Buffer Zone. The specific objectives are:

- To conduct Musk deer count in SNP and its Buffer Zone applying appropriate methods;
- To identify the Musk deer habitat in SNP and its Buffer Zone and prepare GIS based map of the suitable habitat of Musk deer in SNP and its Buffer Zone;
- To prepare technical report on status of Musk deer in Sagarmatha National Park and its Buffer Zone.

The data were collected from field surveys. Methods such as transect walk, scan sampling, ad libitum sampling, collection of indirect evidences like hoofmarks, fecal matters, carcass,

bones and remains of body parts, bedding sites, etc were used. Supposed habitat of musk deer in Sagarmatha National Park and its buffer zone was also surveyed.

During the transect line survey of 15 days' time (June 8-23) in SNP, altogether 52 direct observations, 5 killed and 1366 pellets of musk deer were found. Two species of musk deer (*Moschus fuscas* and *Moschus chrysogaster)* were recorded (as of morphology and body fur coloration) during the survey by direct counts. There were more than 266 fresh pellets piles which were positive sign of each individual and can be estimated as their presence. Several pellets, piles and beds of musk deer were observed in different sites of SNP of different age categories. The number of fawns accompanying each female or family group can provide an indirect estimation the reproductive potentials of musk deer. About 650 piles of pellets that were fresh to very old that is about 6 months to 1 year old were found in several sites. Five musk deer that were killed, most probably by common leopard, were also recorded during the field observation.

The habitat of musk deer in SNP were mainly dominated by the Bhojpatra trees (*Betula utilis*) followed by Rhododendron (*Rhododendron* spp.), Pine trees (*Pinus* spp.), Angeri (*Melostoma normale*), Bains tree (*Aloidendron barberae*) with ground vegetation Khar (*Poa* spp and *Carex* spp), Himalayan bamboo (*Arundinaria* spp.), Orchids, Chutro (*Barberis aristata*) etc. Based on direct sightings and fecal matter/pellets/dung pile, Musk deer preferred around 3800 m to 4000 m altitude.

There are some positive signs for the future of wildlife and musk deer conservation in SNP. There is a high public awareness about wildlife conservation, an appreciation for wildlife and natural resources, and a desire for developing eco-tourism. The future growth and expansion of the human population into the musk deer habitat, the growing awareness of market trends facilitated by new communication links and mass media, and political instability will expose musk deer to increased hunting pressure and negatively impact habitat potentials. A well-managed, carefully handled awareness campaign combined with equitable use of wild resources will be needed to engage local communities with musk deer conservation efforts in SNP. Extensive surveys of musk deer in the surrounding valleys using the protocols suggested in this study will help better understand the population dynamics of the musk deer.

Chapter One: Introduction

1.1 Background

Himalayan musk deer (*Moschus chrysogaster*) is a small (10 kg), stocky built, primitive deer like ruminant. Males lack antlers, and females have a single pair of teats. It possesses well developed canine teeth, hind legs of musk deer appear longer than forelegs, indicating the tendency to move by leaping when browsing the shoots. Elongated dew claws and low weight on tracks facilitate to the movement on snow and rocks and even climb to browse on trees (Green, 1986; Shrestha, 1989; Kattel, 1992; Shrestha, 2003; Chalise, 2008). Both sexes have conspicuous outstanding ears to detect danger. Adult males possess large abdominal scent gland i.e. musk pod, the feature from which its name is derived and have downward curving canine teeth from upper jaw up to 5.41cm long which are used in territorial defense during the rut period (Kattle, 1992) and against any attack of predator. In females and juveniles, canines are shorter and invisible. Body weight of males is less than females. Large size females have an advantage in intra-sexual competition for mates (Trivers, 1972). Big mother hypothesis is most relevant to Musk deer *i.e.* a fawn born from larger female should be able to achieve a larger size prior to onset of long and harsh winter (Barrette, 1987).

Musk deer are shy, solitary animals famous for the musk secreted by the adult male. Musk has been one of the oldest raw materials used in perfumery and traditional medicine in Asia, representing one of the most valuable scented animal products, even more expensive than gold (Green, 1986; Shrestha, 1998).

The habitat of musk deer is characterized by small valleys between steep inaccessible ridges at the upper limits of the tree line (Roberts, 1997). Though solitary they use communal latrines helping to maintain separate territories (Qureshi et al., 2004). Smaller latrines are often found in 50m radius of its day resting sites. As a crepuscular animal, it remains active at dusk and dawn in search of food. This deer is the smallest of Himalayan ungulates living in the cold environment (Kattle, 1992).

Musk deer are killed to get musk pod found in mature males. The high value of musk has been an incentive for illegal hunting of musk deer. Hunting methods often by setting snares, do not discriminate age and sex of animals and both females without musk gland, and juveniles, which secrete little musk in case of males, are also killed along with adult males (Schaller, 1977; Green, 1986; Khan et al., 2006).

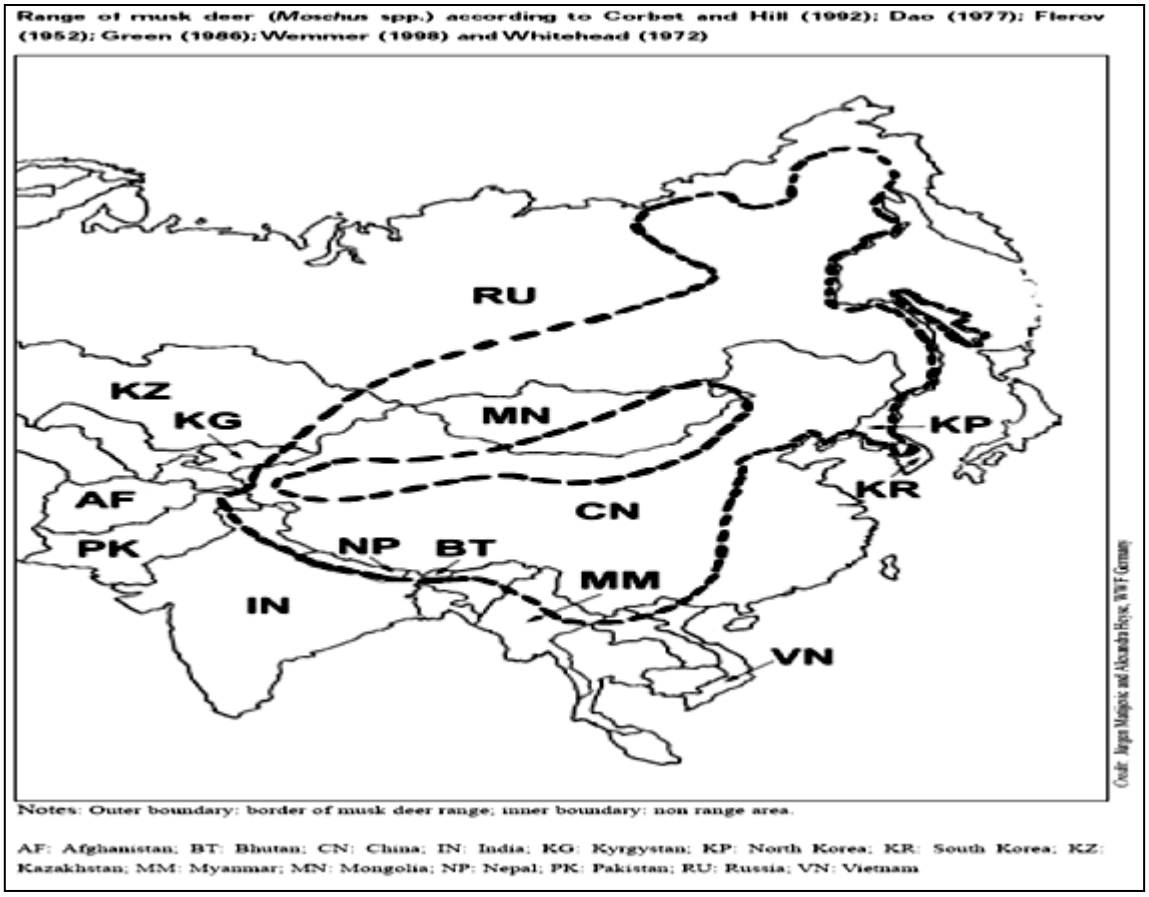


Figure 1: The range countries of different species Musk deer (Homes,V. 1999)

Musk deer is listed as an endangered species and protected mammal in National Parks and Wildlife Conservation Act 1973 of Nepal. CITES listed it differently in its range countries (Figure 1) such as: Appendix I for Afghanistan, India, Nepal and Pakistan while under Appendix II for Bhutan and China. Nepal does not have concrete data about the population of musk deer till to date. Not only in Sagarmatha area but also to Nepal (except few locations), musk deer conservation status is unknown due to scanty information throughout the country (Karki, 2008). At present, musk deer of different subspecies are recorded throughout the globe and they are reported along Himalayan range of different national park and outside the protected area in Nepal (Chalise, 2008, 2012). They have good reproductive capacity and usually thrives their numbers however; human activities; over exploitation and habitat loss have jeopardized survival of Musk deer in the world (Jiang 1995 cited in Karki, 2008).

1.2 Taxonomy of Musk Deer

Musk deer (*Moschus chrysogaster* Hodgson, 1839) is a typical middle-sized mammal of higher Himalaya so it is also called Himalayan musk deer. Kasturi mirga is its Nepali name.

Musk deer was originally classified as members of the family Cervidae (Flower, 1875), however, more recently they are regarded in a separate family Moschidae (Flerov, 1952). It lives along the Himalayan range countries such as in Nepal, northern India, southern China, Afghanistan, Bhutan and Pakistan (Shrestha, 1989). In Nepal, the species is recorded in Kanchanjunga Conservation Area, Makalu Barun National Park, Sagarmatha National Park, Langtang National Park, Manaslu Conservation Area, Annapurna Conservation Area, Khaptad National Park, She-Phoksundo National Park and Rara National Park (DNPWC 2004).

Musk deer is listed as an endangered species and protected mammal in National Parks and Wildlife Conservation Act 1973 of Nepal. CITES listed it under Appendix I for Nepal. They are distributed throughout the mountainous regions of Nepal which covers 30177.19 km^2 with 5815.08 km^2 of potential habitat used inside protected areas (Aryal and Subedi, 2011) from western to eastern part of Nepal including Api Nampa Conservation Area (ANCA), Khaptad National Park (KNP), Rara National Park (RNP), Dhorpatan Hunting Reserve (DHR), Annapurna Conservation Area (ACA), Manaslu Conservation Area (MCA), Langtang National Park (LNP), Gaurishankar Conservation Area (GCA), Makalu Barun National Park (MBNP), Kanchanjunga National Park (KNP) and Sagarmatha National Park (SNP) (Aryal et al, 2010; Aryal and Subedi, 2011). In these areas, they are distributed in Alpine forest and the vegetation is oak, fir, rhododendron, blue pine, juniper, grass, lichens and scrub between elevations of 2,200 to 4,300 m on the eastern and southern edge of Tibet and the southern slopes of the Himalayas.

1.3 Habitat and Ecology

Musk deer does not bear antlers. The body is dark brown. Color of the coat composed of brittle hairs and slightly grizzled sandy brown. Its chest has a wide vertical whitish-yellow stripe which extends up the throat to the chin. Body reaches up to 80 to 100 cm long and shoulder height 50 to 70 cm (Negi, 1996). The ears are tipped with yellow or orange hairs. On the nape of the neck are several horizontal blotches of yellowish hairs. It weighs about 13 to 18 kg (Zhivotshenko, 1988). The body slopes forward, as the hind legs are almost one third longer than the forelegs. Musk deer is a very shy, solitary territorial animal. Its rearmost pan is slightly elevated for jumping and galloping mode of life. The hind legs therefore measure 5 cm longer than forelegs. The fawns are often spotted. Male- female of

Moschus chrysogaster both have well-developed upper canine teeth about 10 cm long used for defense. It looks like a small deer with long upper canine that are visible even when the mouth is closed. Its tail is hairless except for a small tuft at the end. Elongated dew claws and low weight on tracks facilitate to the movement on snow and rocks and even climb to browse on trees (Chalise, 2008).

Musk deer is crepuscular, thus becomes most active between dusk and dawn. Usually found at an altitude of 3000 to 4000m (Karki, 2008). They can be seen grazing in open areas at night. They remain in dense cover during the day time. Usually, musk deer use common latrines (Huffman, 2004). Musk deer are solitary. The Himalayan musk deer does not undertake any seasonal migrations, remaining in the same area year-round despite harsh weather conditions. It holds good hearing and locates sources of danger. In case of frightened, it makes broad leaps of up to 6 meters long. Communication between individuals is thought to be based primarily on their sense of smell, due to the high development of the glands of Musk deer. The presence of the musk gland (pod) is one of the characteristics features of the species, which is present only in the male (Pandey and Chalise, 2011).

They have good life span of about 20 years. They become sexually matured between 16-24 months. Musk deer gives birth to 1 or 2 per litter. Musk deer mate primarily in November-December and give baby birth in May to June. The gestation period remains at least 6 months. After birth, the young deer lies hidden in secure areas. Mother deer meets baby at feeding times. This hiding period may last up to two months. Musk deer does hold both browsing and grazing habits. It primarily feeds upon the tree leaves, grasses, moss, lichens, shoots and twigs. It prefers lichens, eats bark and does exhibit unique type of behavior of climbing to feed lichens (Negi, 1996).

The principal investigator (MKC) has experienced in Langtang National Park (Pandey and Chalise,2011) and Api Nampa Conservation Area and has published a report in DNPWC journal (Chalise and Thagunna, 2014) and also described the species level in the popular paper on population investigation and species characteristics in the academic book too (Chalise, 2014, 2016).

The recent study in Sagarmatha National Park reported only 39 musk deer (11 male, 16 female, and 12 unidentified) in Debuche, Tengboche, Phortse, Thanga, Dole and the associated areas during the field survey in Sagarmatha National Park. Musk deer was

distributed over approximately 131 km^2 of the Park area, in the forests of the Khumjung, Namche and Chaurikharka VDCs. In Khumjung VDC, musk deer have a wider range of suitable habitat than in others. Musk deer were reported to be found in the forests of Kyanjuma, Tasinga, Phungithanga, ThuloOdhar, Nagdin, Tengboche, Phortse, Thanga, PhortsePakha, and Dhole (4,200 m). In Namche VDC, they were found at Top Danda, Furte, Thamo, Pare and Thame. They were also sighted at Jorsalle and KongdeDanda in the Chaurikharka VDC outside the Park Boundary. Only few studies have been conducted on musk deer and there is very limited information available on musk deer in SNP. On the other hand, the data on population status in SNP is lacking. Thus, there is a need to conduct musk deer count in Sagarmatha National Park and its Buffer Zone to update the population status of musk deer in Sagarmatha National Park and its Buffer Zone.

1.4 Objectives of the study

The main objective of this assignment is to update the population status of Musk deer in Sagarmatha National Park and its Buffer Zone. The specific objectives include:

- Conduct Musk deer count in SNP and its Buffer Zone applying appropriate methods;
- Identify the Musk deer habitat in SNP and its Buffer Zone and prepare GIS based map of the suitable habitat of Musk deer in SNP and its Buffer Zone;
- Prepare technical report on status of Musk deer in Sagarmatha National Park and its Buffer Zone.

Chapter two: Literature review

Musk deer '*Moschus chrysogaster*' belongs to order- Artiodactyla, family- Moschidae and is found in Asia. Musk deer is a protected mammal and listed as an endangered species by the National Parks and Wildlife Conservation Act 1973 in Nepal. It is listed in Appendix I for Afghanistan, India, Nepal and Pakistan, and in Appendix II for Bhutan and China under CITES. It is distributed in Afghanistan, Bhutan, China, India, Myanmar, Nepal, and Pakistan. In Nepal, it is found in the entire mountain district including the Sagarmatha, Langtang, Shey Phoksundo, Rara, Khaptad and Makalu Barun National Parks Annapurna Conservation Area (ACA), Kanchenjunga Conservation Area (KCA), and Manaslu Conservation Area, where a major problem is poaching (HMG/N, 2002). In these areas, they are distributed in Alpine forest and the vegetation is Himalayan bamboo, Oak, Fir, Rhododendron, Blue pine, Juniper, Grass, Lichens and scrub between elevations of 2,200 to 4,300 meters (7,250-14,200 feet) on the eastern and southern edge of Tibet and the southern slopes of the Himalayas. *M. chrysogaster* usually lives in forests with moderate to steep slopes (Green, 1987; Kattel, 1992).

Himalayan Musk deer are essentially solitary animals having 12-20 year life span. The male is territorial. But, females appear to be noticeably tolerant of other individuals. Average home range of males is larger than that of females (Kattel, 1992). The presence of the musk gland (pod) is one of the characteristics features of the species, which is present only in the male (Shrestha, 1989).

Musk deer is reported to face predator pressure from Leopard (*Panthera pardus),* Clouded leopard *(Neofelis nebulosa*), Snow leopard (*Uncia uncia*), Lynx (*Felis lynx*), Wolf (*Canis lupus*) and Wild dog (*Cuon alpinus*) (Shrestha, 1981).Populations of musk deer are poached for the musk gland that fetches enormous amounts of money through illegal international trade. Population of Musk deer is decline due to poaching, high human and domestic livestock pressure, consequent degradation of habitat and, in respect of poaching, it has been estimated that for every male deer that yields one musk pod, four deer are killed (Green, 1986; HMG/Nepal, 2002).

The musk produced by this genus of primitive deer is highly esteemed for its cosmetic and all pharmaceutical properties and can fetch US$ 45,000 per kilogram (2.2 pounds) on the

international market. Although, this musk produced in a gland of the males can be extracted from live animals, most "musk-gatherers" kill the animals to remove the entire sac, which yields only about 25 grams (1/40 of a kilogram) of the brown waxy substance (Green, 1986; Knowler, 2000). Musk deer (*Moschus chrysogaster* Hodgson, 1839) is a typical middle-sized mammal of higher Himalaya so; called Himalayan musk deer. In Nepali it is called Kasturi mirga . Musk deer originally classified as members of the family Cervidae (Flower, 1875), however, more recently they are regarded in a separate family *Moschidae* (Flerov, 1952).

In China, scientists have experimentally proven that musk deer products can be used from musk deer breeding center and, also thousands of musk deer have been reared in musk deer centers. Many people have got employment opportunities from these centers as well. The same technique can also be made effective in case of Nepal. However, suitable laws and effective measures should be made and properly implemented beforehand (Chalise, 2014).

Musk deer *Moschus* spp. are found in at least thirteen countries in South Asia, East Asia, Southeast Asia and the eastern part of Russia (Zhou et al., 2004). There are three species of Musk Deer found in Nepal; *Moschus chrysogaster, M. leucogaster and M. fuscus. M. chrysogaster* is found throughout Nepal whereas *M. leucogaster* and *M. fuscus* are found respectively in mid-western to Eastern Nepal (Baral and Shah, 2008). In Annapurna Conservation Area, only *Moschus chrysogaster* have been recorded so far (Bhuju et al., 2007) *Moschus chrysogaster* occurs from the highlands of central China (the Helan mountains form the northern edge of the distribution), south and west to the Himalayas, extending to eastern Nepal, Bhutan, and northeastern India (Sathya kumar, 2002; Wemmer, 1998). *Moschus leucogaster* occurs in the Himalayas of Bhutan, northern India (including Sikkim), Nepal and China (southwest Xizang) (Groves et al., 1995; Grubb, 2005).

Musk deer have been reported from the altitudinal range of 2200 m to 4400 m in Nepal in Sagarmatha National park, Langtang National Park and its Buffer Zone, Kanchanjunga Conservation Area (KCA), Arun Valley, Makalu-Barun National Park and its Buffer Zone, Manaslu Conservation Area and Annapurna Conservation Area (ACA), Shey-Phoksundo National Park and its Buffer Zone, Dhorpatan Hunting Reserve and Rara National Park (Kattel, 1992 and Green, 1986). The population of 600–800 individuals in Sagarmatha National Park (Kattel, 1992), below 1000 individuals in the Shey-Phoksundo National Park (Green 1986), 281 individuals in Langtang National Park and its Buffer Zone (Sharma et.al., 2008) and 310 individuals in KCA (Sharma et.al. 2008) have so far been estimated.

Aryal et al. (2010) found that musk deer randomly use the habitat below 3000 m and completely avoid habitat above 4000 m in Sagarmatha National Park, while Green (1985) recorded the musk deer within the altitudinal range of 2500-4500 m. Musk deer is commonly found in SNP between 2,500-4,000 m where the area is covered by Birch (*Betula utilis*), Fir (*Abies spp.)* and Rhododendron (*Rhododendron spp.).* It is also recorded from *Pinus wallichiana* and *Arundenaria* forests, and sometimes it comes out to open grasslands and potato fields. Musk deer is mostly found in Tengboche, Tasinga, Phortse, Pangboche, Dole, Kyanjuma and Syangboche areas (SNP, 2004, Rajchal, 2006). Approximately 49 km area of the SNP is considered as suitable habitat for musk deer (SNP, 2004).

Although habitat fragmentation, loss and degradation may pose a serious threat to the musk deer population, the primary threat is attributed to poaching (Wemmer, 1998; Green, 1986).

Despite conservation efforts implemented through enactment of law and designation of protected areas, the species remains susceptible to likely negative impacts of livestock grazing in their range (Aryal *et al.* 2010).

Although protected areas play an important role in conservation, their effectiveness is limited by human-induced stresses. In high altitudes of Nepal, people depend on livestock rearing and forest resources for their sustenance. Livestock experience transhumance foraging systems where they move to different pastures and forests in the high altitudes for foraging (Metz, 1990; Fox *et al.*, 1996) which are presumably the potential habitat for native wildlife including musk deer. However, impacts of livestock grazing on mountain ungulates including musk deer habitat appear to be overlooked and their repercussions have received little attention recently (Mishra et al., 2004; Namgail et al., 2007). Thus, it's crucial to identify the habitat conditions (topographic and vegetation features) that characterize their selections (Boyce et al., 2002) to explore any possible impacts. Research on musk deer has been undertaken only in few protected areas of Nepal and includes conservation needs, initial population status, habitat ecology of the species and threats in order to determine the necessary conservation initiatives.

Chapter three: Methodology

3.1. Study area

Sagarmatha National Park (SNP), established in 1976 is one of the pioneer protected areas of Nepal. The park was inscribed as world heritage property in 1979 because of its superlative and exceptional natural beauty, which is embedded in the vivid mountains, glaciers, deep valleys and majestic peaks including the world's highest peak, Mt. Everest. The Gokyo and the associated wetlands, the wetlands of global significance, also lie within the Park. The park is a home to some of the endangered wildlife species including snow leopard, musk deer and red panda. The area contains the world's highest ecologically characteristic flora and fauna, intricately blended with the rich Sherpa culture.

The Buffer zone, encompassing the major part of the Chaurikharka VDC to the south as well as the settlements within the SNP traditionally considered as village enclaves, was created in 2002. There are nearly 7,800 people living in 1,619 households in the buffer zone of the SNP (Fig 1).

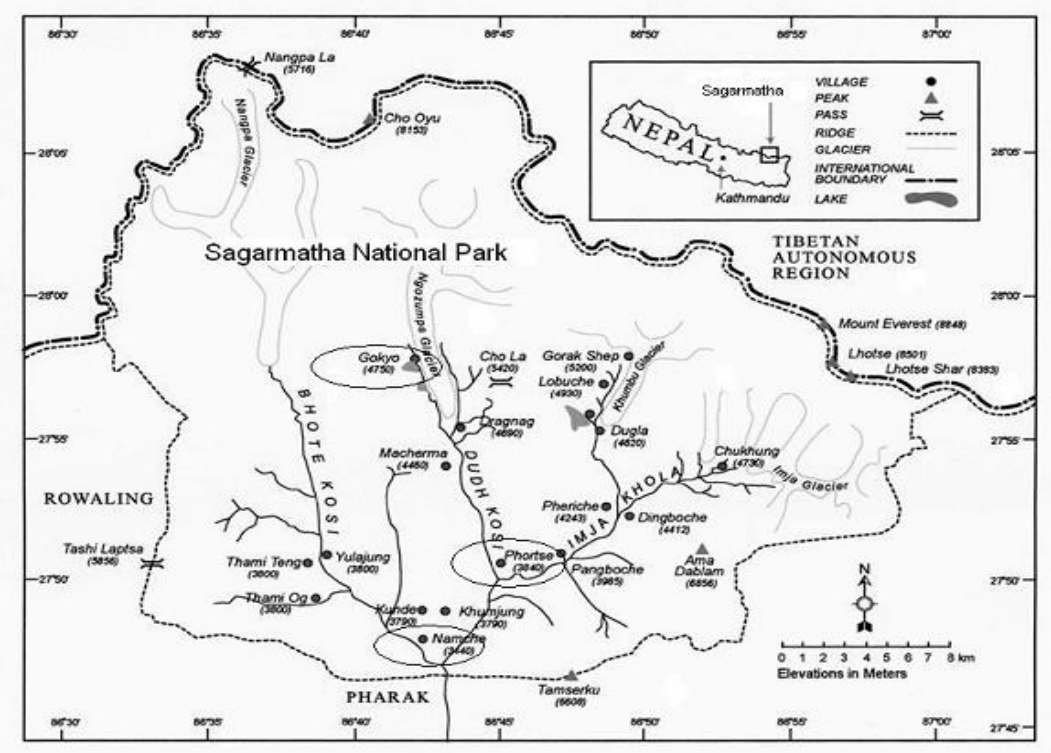


Figure 2: Location map showing Sagarmatha National Park and its buffer zone

SNP has a comparatively low number of mammalian species as a result of the recent origin of the Himalayas and climatic factors. The main mammals found are snow leopard (*Panthera uncia*), Himalayan musk deer (*Moschus chrysogaster*), Himalayan black bear (*Selenarctos*

thibetanus), red panda (*Ailurus fulgens*), Himalayan tahr (*Hemitragus jemlahicus*) and wolf (*Canis lupus*). Many of these mammals are listed as endangered or threatened species. Musk deer in SNP has been reported at elevations between 3000−4200 m in SNP. However, they can be sometimes observed in lower parts at an altitude of 2800 m (Jorsalle). They are distributed from Tasinga, Chhuwa, Lausasa, Seluwa, Kyanjuma, Phungithaga, ThuloOdar up to Shyangboche (3,720 m); from Debuche, Omaka, Milunga, Yaranga up to Pangboche (3,930 m) on the way to the Island Peak; from Mongla (3,973 m), PhortseThanga, PhortsePakha, Phortse up to Dole (4,200 m) on the way to Gokyo and from Furte, Pare up to Thamo (3,493 m) on the way to Gokyo.

3.2. Materials and methods

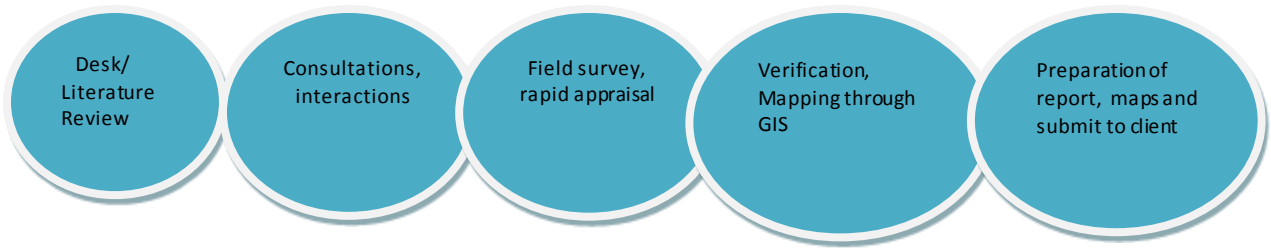
3.2.1 Materials used

We used binoculars of 10x40 lenses for each major group leader, camera with telezoom lenses up to 1200 and 12 to 18 megapixels, while each investigating team has GPS, measuring tape, and other accessories for field. We have a refresher field practice of a day to all participating field assistants that included all park staffs (up to 30 game scouts including rangers and Park warden) in nearby forest for the observation and estimation of pellets piles/ dung-piles age.

3.2.2 Approach

The approach to count Musk deer in Sagarmatha national park was generally based on Situation Analysis through Desk review, Consultations, Field survey and Analysis method through **Participatory and Consultative, Multi-Perspective and Communicative, Disclosure and verification approaches.** The service provider carried out the assignment with the fallowing key approaches:

3.2.3 Schematic view



3.2.4 Methods

3.2.4.1 Field Survey method:

The study was focused on Musk Deer, and because it was difficult to observe a Musk deer, the survey used secondary sources such as signs in order to know the biodiversity and suitable habitat for musk deer. The vegetation study was proposed to reveal more about the habitat use and the amount of potential habitat for Musk deer. The vegetation study also suggested whether the proposed area belonged to any corridor and connectivity landmass for Musk deer.

a) Transect walk: Field surveys were conducted by following line transect and point count methods (Bibby et al., 1992). The line transects were laid randomly, one in each major habitat of the forest closed canopy, grassland, open canopy and degraded areas near the forest edge. Also point counts were conducted along the line transects of each habitat on different days. Points were of maximum 50 m radius; at least 100 m apart from each other to avoid overlap and counts or observation were done within 5-minute duration. In each habitat, more than 3-point count surveys were carried out. All the counts were carried out early morning, during the first three hours after sunrise as counts needed to be carried out at the time of highest Musk deer movements (Chalise, 2003, 2009, 2014). Opportunistic observations (ad libitum sampling) were added to the list so as not to miss the species during the survey period. Musk deer were identified using books (Shrestha 1997; Chalise 2008, 2014). While walking for identification of potential habitat for Musk deer, the effort was targeted to find out its population, density, feeding habitat, breeding ground and also behavior.

b) Scan sampling: 10 minutes scan sampling was performed (as described in Chalise, 2003, 2009) to find out Musk deer population. It was repeated several times in each day observation with shifting of the observation site in an hour interval. It was performed in each important and significant site of proposed area.

Census: Distance Sampling was used to estimate density of the population. In this case, line transect sampling was used and during the travel along transect records and count the presence of Musk deer was made. When seeing the animal, the following parameters were recorded: - the number and the composition of the group encounter, the distance between the observer and the first one seen.

These different parameters are needed in the calculation of the density and the abundance of the population. Along the line transect, flag was put every 25m to facilitate the localization of

the encountering point where the Musk deer was seen. The GPS geographical coordinates of the encountering points were recorded. Census was conducted from 6:00 to 10:00 am in the morning and 3:00 to 6:00 pm in the evening for 2 days in each location. The census team was composed of the Principal investigator and two university graduates; two local personnel were hired for local support as guides and porters.

c) Ad libitum sampling: A continuous recording of the data during the forest walk was performed; whenever any new information perceived, it was recorded (Chalise, 2008, 2009).

d) Indirect evidences collection: The sign of Pug marks / Foot prints of Musk deer, droppings and marking in the trees, nests, holes and burrows, cry, smell or odor; leftover food items; trampling of plants; etc. were all recorded. The carcass, bones and remains of Musk deer parts were also noted. All those noticeable evidences of the field were recorded by camera and GPS too and filled out the format as given. The indirect evidences were supported by information from local people generated by questionnaire surveys or semi-structured interviews.

e) Vegetation sampling: Different forest types and vegetation pattern were observed and categorized according to altitudinal variation. The status of the forest, species richness, species dynamics, and regeneration pattern and community structure were explored by quadrate sampling methods. Thus, samplings were carried out in the different forest and ecosystem types. The plot sizes were 10x10 m for tree, 5x5 for shrub and 1x1 m for herbaceous vegetation (Simpson, 1949, Sharma 1997, 1999). The samplings were carried out in all major forests, grasslands, rangeland, shrub lands and herbaceous vegetation types. There were at least 30 plots in each type. During sampling the plant species were identified based on literature and for unidentified species the sample were collected, and herbarium was prepared which was identified later in botany and herbarium departments.

Furthermore, to acquire full information following methods were also procured.

3.2.4.2 Population estimation and threats

Silent Drive Count (SDC, Fig 2) method was used to estimate population of Musk deer (Vinod and Sathyakumar, 1998). Plots at least size of 20 x 20 sq. m were established on potential habitat. The size of plot was depending on level of ground, natural boundaries and visibility. For example, a landscape possesses stream at both side considered as one plot, a

landscape possess uniform level was considered as one plot. Total 5 plots in Ghusa VDC were established. Total 4 men and two researchers were deployed at interval 50m or as per topography and forest density more or less distance to drive Musk deer towards enumerators from different sides. Enumerators were deployed at two corners of plot, so that they can count derived Musk deer.

Other indirect signs, such as sleeping or resting sites and pellet were also recorded. Musk deer selects resting sites under stone and tree and they create round or oval type mark where they roost. Musk deer defecates on same point from a long period and pellet can be easily separated from other deer due to its scent and huge pile. Threats were recorded by direct observation of poaching related activities such as movement of poachers, presence of snares and gun fires. A protocol was developed to gather information on population and threats.

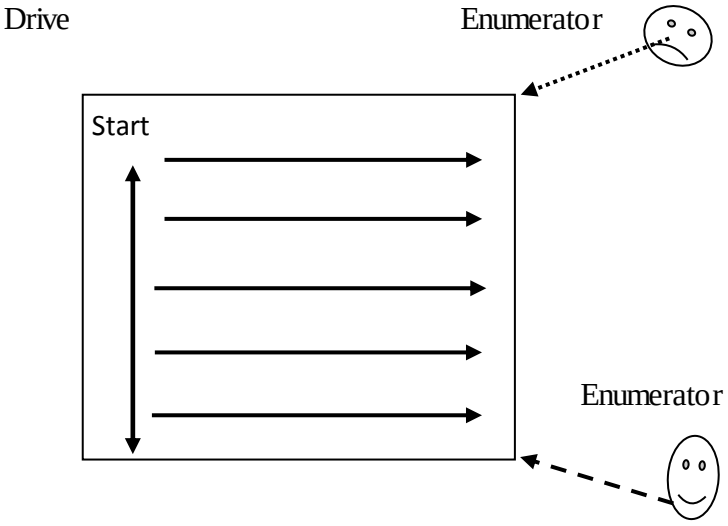


Figure 3: Pictorial representation of Silent Drive Count.

3.2.4.3 Habitat survey

Habitat survey includes survey of vegetation and physical parameters. During the survey of vegetation, the habitat was divided into three strata according to the types of forest; Conifer Forest, Betula Forest and Mixed Forest (Conifer and *Betula* species). Plots of size 20 x 20 sq. m and 1 x 1 sq. m were established for the survey of trees and herbs respectively (Fig 3). Total 10 plots were laid out to collect data on trees and shrub species. Other parameters such as undergrowth vegetation, crown cover and land configuration were collected. Physical parameter such as Altitude, Latitude and Longitude were recorded by using hand held GPS. A protocol was developed to gather information on habitat impact and analysis.

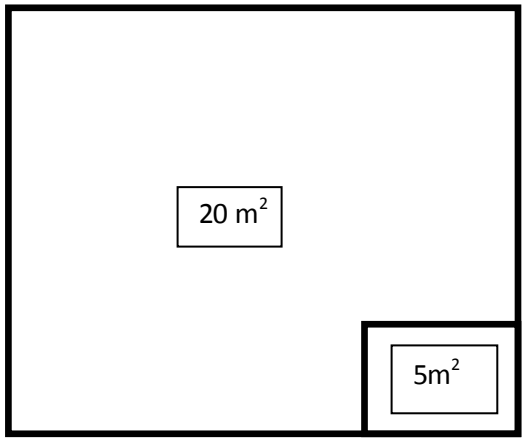


Figure 4: Plot Designs to record density of tree and shrub along with species.

3.2.5 Secondary data collection

Secondary data relevant to the study was gathered from different organizations related to the study, just before starting of the field work, and even during the work. Those kinds of secondary information was collected from different libraries including Department of National Parks and Wildlife Conservation, World Wildlife Fund Nepal, National Trust for Nature Conservation, and several other libraries in Kathmandu. Various articles, journal, newspapers were downloaded from internet too.

3.2.6 Analysis methods

The data obtained from the scan sampling and transect walk were added together to form the total count and according to the different habitats corresponding densities were calculated. The time interval of observed Musk deer focused on the frequency and abundances of Musk deer in the area (Chalise, 2003). The abundance of Musk deer in particular habitat types were calculated by making percentage ratio of number of quadrates having indirect sign with total number of plot sampled. Habitat preference by the Musk deer was calculated as the relative value of the number of plot having the Musk deer sign divided by total number of studied quadrate.

Chapter four: Results

During the transect line survey of 15 days' time (June 8-23) in SNP altogether 52 live recorded, 5 killed noticed and 1366 pellets of musk deer were found by direct observation.

4.1. Direct observations

Altogether 52 individuals of musk deer were recorded by direct sightings in different forests of Sagarmatha National Park (SNP) ranging from the altitude of 3328 m to 4041 m (Table 1). The number includes the fawns with mother or wandering alone. The categories of musk deer we did of two subspecies on the basis of morphology and specially by the coloration of their fur (Fig 4). The forest musk deer are comparatively black tint color throughout the body fur while alpine musk deer has the whitish patch at the neck region.

Figure 5: Musk deer observed in different locations of the study areas

The lowest site of musk deer sighting was Chhuwa with an altitude of 3451 m whereas Dole and Kele jungle was the highest point where musk deer was recorded with an elevation of 4041 m.

Among the 52 individuals of live sightings during forest walk, 14 were males and 32 were females whereas 6 were fawns whose sex could not be determined (Figure 6). Adults 19 individuals of Black musk deer (*Moschus fuscas*) and 16 individuals of Alpine musk deer (*Moschus chrysogaster*) were recorded during the survey by direct counts (Figure 7). These

two species were identified by their fur coloration, and proportionate size. Male's weight was found to be up to 18 kg while female weight was found to be up to 15 kg in normal adult form.

Table 1: Direct sightings of musk deer in different sites of SNP

SN	Area	Coordinates	Altitude (m)	Number Male/Female	Total	Species Morphologically
1	Khochefurte	N 469664 ; E 3077346	3689	1 Female	3 +1 = 4	*M. fuscus*
2	Khochefurte	N 469346 ; E 3076551	3451	1 Female		*M. chrysogaster*
3	Khochefurte	N 469535 ; E3076196	3409	1 Male+1 Female		
4	Phorche	N 475574 ; E 3079080	3669	1 Female+1 Fawn	4+ 1 = 5	*M. fuscus*
5	Phorche	N 475208 ; E 3079155	3460	1 Female		*M. fuscus*
6	Phorche	N 475452 ; E 3079145	3573	1 Female		*M. fuscus*
7	Phorche	N 474412 ; E 3079669	3640	1 Female		*M. chrysogaster*
8	Omaca	N 478253 ; E 3080379	3754	1 Female	1	*M. fuscus*
9	Panbuche	N 478711 ; E 3080870	3764	1 Female	1	*M. chrysogaster*
10	Dole and Kele	N 473848 ; E3082840	3882	1Female +1 Fawn	10 + 6 + 3 = 19	
11	Dole and Kele	N 473202 ; E 3083937	4151	1 Female		
12	Dole and Kele	N474073 ; E 3080966	3982	1 Male		
13	Dole and Kele	N474017 ; E 3081175	3942	1 Female		
14	Dole and Kele	N 473755 ; E 3081965	3990	1Female+1Male+ 1Fawn		*M. fuscus*
15	Dole and Kele	N 473825 ; E 3082536	3929	1Female + 1 Male		*M. fuscus*
16	Dole and Kele	N 473612 ; E 3083125	3939	1 Female		*M. chrysogaster*
17	Dole and Kele	N 473545 ; E 3083105	3933	1Female +1 Fawn		*M. fuscus*
18	Dole and Kele	N 473516 ; E 3082972	4000	1 Male		*M. chrysogaster*
19	Dole and Kele	N 474449 ; E 3079666	3620	1 Female		*M. chrysogaster*
20	Dole and Kele	N 474315 ; E 3081145	3771	1 Male		*M. fuscus*
21	Dole and Kele	N 473886 ; E 3081792	3954	1 Female +1 Male		*M. fuscus*
22	Dole and Kele	N 473568 ; E 3083028	4041	1 Female		*M. chrysogaster*
23	Milunga	N 478568 ; E 3080386	3935	1 Male	1+1 = 2	*M. fuscus*
24	Milunga	N 478542 ; E 3080404	3937	1 Female		*M. fuscus*

25	Syangboche	N 472445 ; E3076799	3878	1 Female	3	
26	Syangboche	N 472133 ; E 3076658	3878	1 Female		*M. fuscus*
27	Syangboche	N 472819 ; E 3077089	3855	1 Female		*M. chrysogaster*
28	Tashinga	N 474439; E 3078199	3358	1 Male	1+2 =	*M. fuscus*
29	Tashinga	N 474168 ; E 3078174	3479	1 Male	3	*M. fuscus*
30	Tashinga	N 474433 ; E 3078179	3367	1 Female		*M. fuscus*
31	Tengbuche	N 476289 ; E 3079324	3733	1 Male	1	*M. fuscus*
32	PhungiThanga	N 475072 ; E 3078407	3404	1 Female	3+2 =	*M. chrysogaster*
33	PhungiThanga	N 475017 ; E 3078165	3461	1 Female	5	*M. chrysogaster*
34	PhungiThanga	N 475416 ; E 3078357	3524	2 Fawns		*M. chrysogaster*
35	PhungiThanga	N 474412 ; E 3079669	3640	1 Female		*M. chrysogaster*
36	Chhuwa	N 475002 ; E 3077764	3487	1 Female+1Male	4+3 =	*M. chrysogaster*
37	Chhuwa	N 474726 ; E 3077697	3499	1 Female	7	*M. chrysogaster*
38	Chhuwa	N 475026 ; E 3078291	3329	1 Female		*M. chrysogaster*
39	Chhuwa	N 474727 ; E 3078213	3328	1 Female+1Male		*M. fuscus*
40	Chhuwa	N 475026 ; E 3078291	3328	1 Male		*M. fuscus*
41	Pare	N 468207 ; E 3076766	3601	1 Female	1	*M. chrysogaster*
41 forests Total		***52 live musk deer observed; 14 Male 6 Fawns and 32 Females***				

Musk deer were sighted at 41 forest patches such as Khochefurte, Phorche, Omaca, Panbuche, DoleKele, Milunga, Syangboche, Tashinga, Tengbuche, PhungiThanga, Chhuwa and Pare. The live musk deer we encountered were 52 individuals including 6 fawn, 32 females and 14 males (Fig 6 & 7). These forests were mainly dominated by *Betula utilis*, *Rhododendron* spp., *Pinus* spp., *Melostoma* sp., with ground vegetation dominated by *Poa* spp, *Carex* spp, *Barbaris aristata* and so on. The canopy cover of these forests was 45-75%.

Live animals were observed more in the cold and moist area rather than warmer area as the data shows more musk deer were observed in north and north-west aspect and less were found in southern aspect. Dole and Chuya jungle in SNP were found more prominent for live observations which contained Bhojpatra, Gurans, Pine and Dhupi as the major plant species and having Khar grass at ground in few open areas in some intervals. Mainly animals were easily available near the water sources.

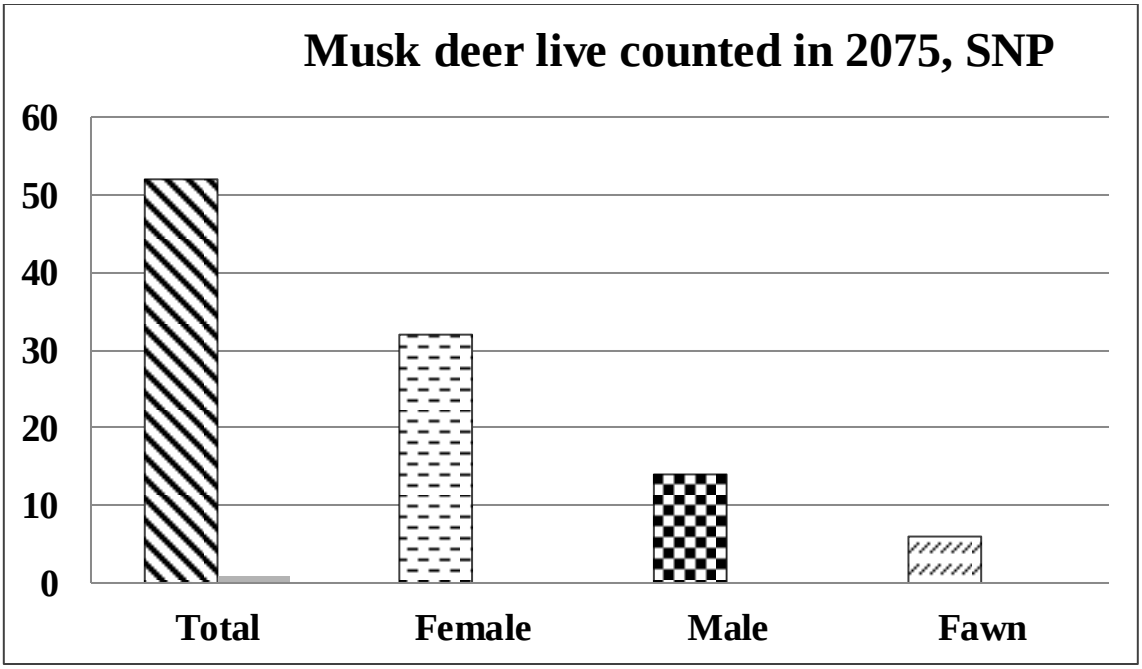


Figure 6: Musk deer observed from direct sightings in SNP, 2075

The individuals that were sighted seemed morphologically in good health, except for one, which was injured. Larger number of live individual encounter showed the suitability of habitat and availability of food resources for the musk deer. However, presence of predators such as snow leopard, common leopard was also recorded through the fecal matters.

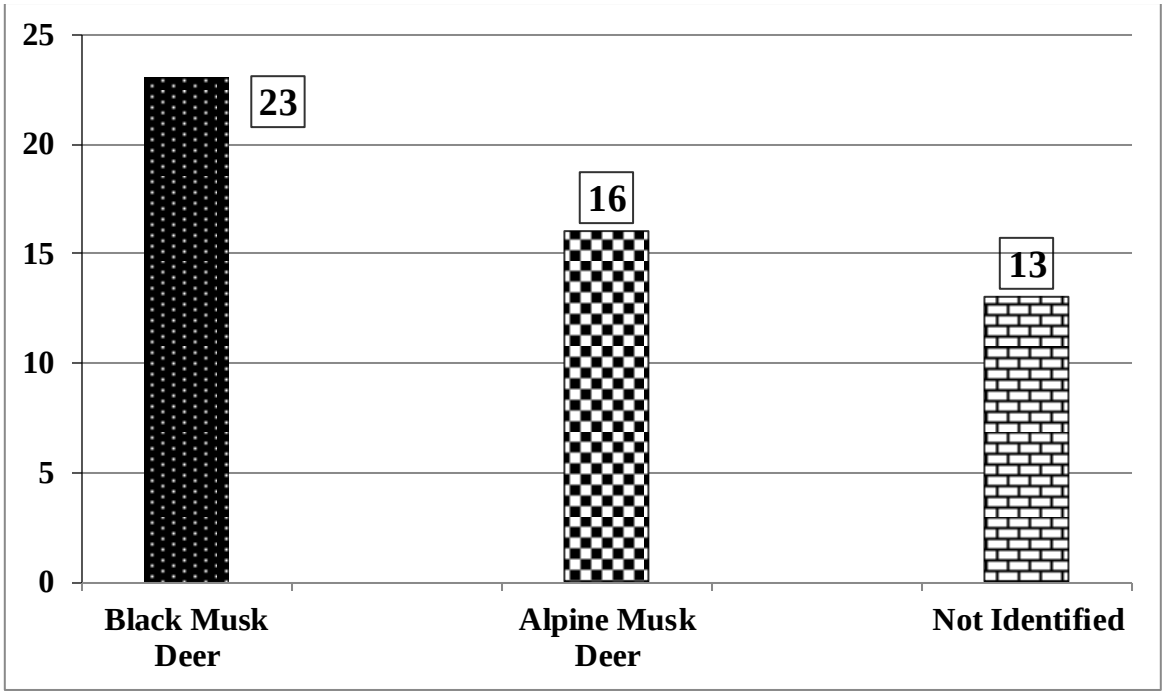


Figure 7: Population of two species of musk deer sighted directly in SNP.

4.2. Pellet count

Musk deer is typical forested ungulates and is very shy, solitary, and lives in mountainous terrain covered by dense forests, which makes it very difficult to observe and survey directly in the field, however, the feces that it left are an effective indicator of habitat selection and population surveying. Several pellets, piles and beds of musk deer were observed in different sites of SNP (Table 2). The piles are categorized by denoting F = Fresh (shining and sticky pellets = One day old and according to topography and direct sunlight may be two days old), F1 = Recent (within one week or maximum one week-old, black, non-sticky), O = Old (Older than one week, may be 2-4 weeks old, de-colored or black color is not very dark) and O1 = 1-6 months old (de-colored with fungus growth and deformed of shape started).

We discarded very old and fungus laden piles as of last year pellets. Such piles may indicate once musk deer roamed around in such habitat but no more recently.

About 266 pellets were found fresh recently with top layer of 1-2 days old piles (Fig 8). Those pellets were found in medium to large piles in the forest area while small piles were found with scattered in open grassland area which indicate deer use grassland as grazing area rather than their settlement. Dole and Kele forests (107) ranging from the altitude of 3745 m to 4175 m and PhungiThanga (47) forest ranging from the altitude of 3394 m to 3690 m contained more pellets with Bhojpatra, Guras, Thingresalla and Nigalo as major dominant species. More over these forests are in NW aspect and are preferred habitat for the deer. Pellets are found more in ridges having substratum soil.

Figure 8: Fresh pellets with some week older can be determined by its stickiness.

The least number of fresh pellets were found in Syangboche (2) and Tasinga (2) forests. The fresh pellets were found also in PhurteKhoche (8), Timurghari (4), Phorche (16), Debuche (10), Tengbuche (9), Omaca (10), Pangbuche (9) and Pare (4) forests. No fresh pellets were found in Chhuwa forest.

Table 2: Fecal matter/pellets/dung pile counts of musk deer at different sites of SNP

SN	Area	Numbers of droppings/piles				Total
		F	F1	O	O1	
1	Khochefurte	15	11	20	5	51
2	Timurghari	6	5	18	14	43
3	Phorche	16	27	61	2	106
4	Syangboche	2	7	10	-	19
5	Tasinga	2	1	5	-	8
6	Debuche	17	53	100	-	170
7	Tengbuche	9	15	24	-	48
8	Omaca	10	10	23	-	43
9	Dole + Kele	107	128	199	7	441
10	Pangbuche	9	18	30	1	58
11	PhungiThanga	47	23	80	1	151
12	Pare	10	19	26	1	56
13	Chhuwa	16	44	110	3	173
	Total pellets piles	**266**	**360**	**706**	**34**	**1366**

a. 1-2 days old

Out of 266 fresh pellets 23 were of babies, 48 were of males and remaining were of females. These all can be included as live animals in the census of musk deer count 2075. Those fresh pellets were still sticky and have very sharp shining color with intestinal mucus. The male pellets still consist of a different odor than female one. The fresh fawn pellets were mostly with female pellets but smaller in size and along with females' dung piles nearby.

b. Within 1 week old

360 pellets were found having top layer fresh up to one week. They were found more in Dole forest (128) ranging from the altitude of 3406 m to 4170 m and Porche forest (27) ranging from the altitude of 3417 m to 3686 m and (Fig. 9). This age types of pellets still have black or dark color but no sticky and shining reflection. They are dry and harder while some might be starting decolorizing its real tone. The forests also include same Bhojpatra, Thengresalla

and Guras as dominant species. Pellets were found more in ridges having substratum soil. The least number of pellets that were about one week old were found in Tasinga and PhurtKhoche forests.

Out of them 26 were of babies, 48 were of males and remaining were of females. As those pellets included more medium to large piles almost 50% pellet can be added in a musk deer number count because remaining 50 % have chance to be already included in the recent pellets due to which the result may be not be biased and the data will not be lost.

Figure 9: Recent and old pallets in dung piles. The counts and categories made along with SNP Warden.

c. Very old

Several piles that were more than a week old and about 1-6 months old were found in various sites. 7 pellets were found with extra-large pile which included very old layers of before 1 year to top layer recent. The largest number of old piles of pellets found were in Dole Kale (199) Chhuwa forest (110) and Debuche forests (100). These indicate these pellets are of permanent deer's in the habitat that don't perform seasonal migration (Fig 10). Almost all these were found under the cave in the loose soil area.

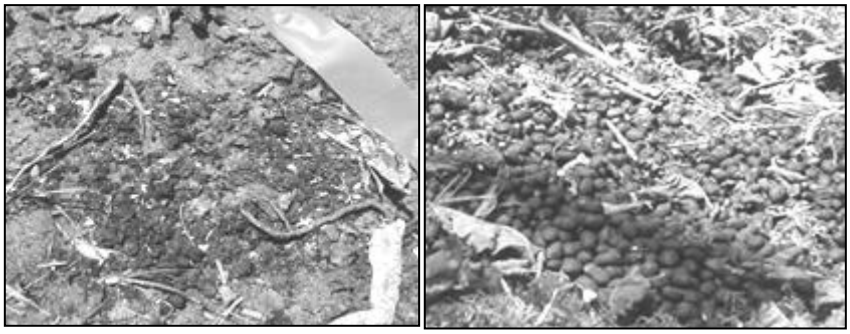


Figure 10: Very old pallet groups in the different part of Chhuwa and Phorche forest.

Bedding sites were also found near the pellets. These include 2 male piles and 5 female piles including baby layers around 2 female piles. No older piles were found in Syangboche, Tasinga, Debuche, Tengbuche, Omaca and Pangbuche.

4.3. Killed

Five deer were found killed by the common leopard (?). The killed area included large pile of hairs, canine teeth, few body parts, etc (Fig 11). A recently killed male deer was found in Phungithanga forest with 2 legs, 2 musk and large piles of hairs. Footprints of common leopard near the killed area had indicated the common leopard as a predator in this high altitude also.

Figure 11: Remains of killed musk deer.

Some areas were identified as the musk deer resting and sleeping sites. Most of the secured places such as under big trees and also vantage points were selected by musk deer to take short rest or to sleep longer.Such spaces were known by the presence of ground level and also with evidence of their fur remains (Fig 12).

Figure 12: Sleeping sites and resting areas were identified in the habitat.

Habitat

These sites were mainly dominated by the Bhojpatra trees (*Betula utilis*) followed by Rhododendron (*Rhododendron* spp.), Pine trees (*Pinus* spp.), Angeri (*Melostoma normale*), Bains tree (*Aloidendron barberae*) with ground vegetation Khar (*Poa* spp and *Carex* spp), Himalayan bamboo (*Arundinaria* spp.), Orchids, Chutro (*Barberis aristata*) etc. Pine species were mostly *Abies spectabilis, Pinus wallichiana* and *Cupressus* sp. Most of the musk deer were seen in Dole and Kele jungle, followed by Phorche jungle, PhungiThangapari jungle, Phurte jungle, Xuwa jungle and Pare jungle. The habitat of these jungles was almost similar, which was suitable for the musk deer. The canopy cover in these habitats of musk deer were about 51-75%. This dense canopy cover provided sufficient forage for the musk deer. The forest type in Sagarmatha National Park is well represented and provides safe refuge and food for musk deer.

4.4.1 Types of Forest in different locations of studied areas

Timurghari area

In this area the forest was dominated by *P. wallichiana,* which accounted for about 80% of the forest cover, *Rhododendron* spp, *Lyonia ovalifolia* and *Betula utilis* accounted for about 20% of the total forest cover. *Pinus wallichiana* was the dominant species throughout the sunny slopes. Many species of Rhododendron, Aangri and *Betula utilis* could also be found but Rhododendron and Aangeri mainly occurred as shrubs. Khar grass was distributed abundantly throughout the area as the undergrowth vegetation.

Himalayans Tahr (*H. jemlahicus*) and Musk Deer (*M. moschus fuscus*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungal cat. Danphe, Monal can be found abundant throughout the jungle.

Chhuwa area (Tesinga Post)

The major tree species observed were *Abies spectabilis, P. wallichiana, B. utilis* and many species of Rhododendron while *Cupressus* sp. mainly occured as shrubs. *Pinus wallichiana* was the dominant species throughout the sunny slopes but the moist slope exposed to the north was dominated by *Betula utilis*. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis, Xanthoxylum nepalensis, Arundinaria* spp, *Daphne bholua*, *Rosa* spp, *Elaeagnus parvifolia, R. lepidotum*, and *Jasminum humile*. The major herbaceous floras

in this range were *Artemisia* spp, *Gentiana strobilacea, Euphorbia wallichii, Stiparoylei* spp, and *Poa* spp.

HimalyanTahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungli cat. Chilme Munal can be found abundant throughout the jungle.

Phorche area

The major tree species observed were *Abies spectabilis, P. wallichiana, B. utilis* and many species of Rhododendron while *Cupressus* sp. mainly occured as shrubs. *Pinus wallichiana* was the dominant species throughout the sunny slopes but the moist slope exposed to the north was dominated by *Betula utilis*. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis, Xanthoxylum nepalensis, Arundinaria* spp, *Daphne bholua*, *Rosa* spp, *Elaeagnus parvifolia, R. lepidotum*, and *Jasminum humile*. The major herbaceous flora in this range were *Artemisia* spp, *Gentiana strobilacea, Euphorbia wallichii, Stiparoylei* sp, and *Poa* spp.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungali cat. Chilme Munal can be found abundant throughout the jungle.

PhungiThangaPari area (Tesinga Post)

The major tree species observed were *Abies spectabilis, P. wallichiana, B. utilis* and many species of Rhododendron while *Cupressus* spp. mainly occured as shrubs. *Pinus wallichiana* was the dominant species throughout the sunny slopes but the moist slope exposed to the north was dominated by *Betula* sp. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis, Xanthoxylum nepalensis, Arundinaria* sp, *Daphne bholua*, *Rosa* sp, *Elaeagnus parvifolia, R. lepidotum*, and *Jasminum humile*. The major herbaceous floras in this range were *Artemisia sp, Gentiana strobilacea, Euphorbia wallichii, Stiparoylei* spp, and *Poa* sp.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungle cat. Danphe, Coal tit, Oriental Turtle Dove, Blood Pheasant (*Ithaginis cruentus*), Large-billed Crow (*Corvus macrorhynchos*), Red-billed Chough (*Pyrrhocorax pyrrhocorax*) were distributed abundantly throughout the jungle.

Pare area (Phurte Post)

The forest was dominated by *B. utilis*, which accounted for about 50% of the forest cover, many species of Rhododendron, Aangri, Bains, *Pinus wallichiana*, *Cupresus* spp and *Abies spectabilis* accounted for about 50% of the total forest cover. Pinus species was the dominant species throughout the sunny slopes. Many species of Rhododendron, Aangri and *Betula utilis* can also be found but mostly to the moist slope exposed to the north. Khar grass was distributed abundantly throughout the area as the undergrowth vegetation. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis*, *Xanthoxylum nepalensis*, *Arundinaria* spp, *Daphne bholua*, *Rosa* spp, *Elaeagnus parvifolia*, *R. lepidotum*, and *Jasminum humile*.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. moschusfuscus*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungle cat. Danphe and Chilme Munal are distributed abundantly throughout the jungle.

Phurte Post Jungle

The forest was dominated by *B. utilis*, which accounted for about 50% of the forest cover, many species of Rhododendron, Aangri, Bains, *Pinus wallichiana*, *Cupresus* spp and *Abies spectabilis* accounted for about 50% of the total forest cover. Pinus species was the dominant species throughout the sunny slopes. Many species of Rhododendron, Aangri and *Betula utilis* can also be found but mostly to the moist slope exposed to the north. Khar grass was distributed abundantly throughout the area as the undergrowth vegetation. The major shrub species observed were *Berberis* spp., *Piptanthus nepalensis*, *Xanthoxylum nepalensis*, *Arundinaria* spp, *Daphne bholua*, *Rosa* sp, *Elaeagnus parvifolia*, *R. lepidotum*, and *Jasminum humile*.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. moschusfuscus*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungle cat. Danphe and Chilme Munal are distributed abundantly throughout the jungle.

Debuche Post area

The major tree species observed were *Abies spectabilis, P. wallichiana, B. utilis* and many species of Rhododendron while *Cupressus* spp. mainly occured as shrubs. *Pinus wallichiana*

was the dominant species throughout the sunny slopes but the moist slope exposed to the north was dominated by *Betula* sp. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis, Xanthoxylum nepalensis, Arundinaria* sp, *Daphne bholua*, *Rosa* sp, *Elaeagnus parvifolia*, *R. lepidotum*, and *Jasminum humile*. The major herbaceous floras in this range were *Artemisia* sp, *Gentiana strobilacea*, *Euphorbia wallichii*, *Stiparoylei* spp, and *Poa* sp.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungle cat. Danphe, Coal tit, Oriental Turtle Dove, Blood Pheasant (Ithaginis *cruentus*), Large-billed Crow (*Corvus macrorhynchos*), Red-billed Chough (*Pyrrhocorax pyrrhocorax*), Snow Pigeon can be in the jungle.

Dole Post area

The major tree species observed were *Abies spectabilis, P. wallichiana,B. utilis* and many species of Rhododendron while *Cupressus* sp. mainly occured as shrubs. *Pinus wallichiana* was the dominant species throughout the sunny slopes but the moist slope exposed to the north was dominated by *Betula* sp. The major shrub species observed were *Berberis* spp, Sunakheri, *Piptanthus nepalensis, Xanthoxylum nepalensis, Arundinaria* spp, *Daphne bholua*, *Rosa* sp, *Elaeagnus parvifolia, R. lepidotum*, and *Jasminum humile*. The major herbaceous floras in this range were *Artemisia* sp, *Gentiana strobilacea*, *Euphorbia wallichii*, *Stiparoylei* spp, and *Poa* spp.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Several signs of common leopard were also sighted along with jungle cat. Danphe, Coal tit, Oriental Turtle Dove, Blood Pheasant (*Ithaginis cruentus*), Large-billed Crow (*Corvus macrorhynchos*), Red-billed Chough (*Pyrrhocorax pyrrhocorax*), are distributed abundantly throughout the jungle.

Syangboche Post area

The major tree species observed were *Abiessp ectabilis, P. wallichiana, B. utilis* and many species of Rhododendron while *Cupressus* spp. mainly occurred as shrubs. *Pinus wallichiana* was the dominant species throughout the sunny slopes but the moist slope exposed to the

north was dominated by *Betula* sp. The major shrub species observed were *Berberis* spp, *Piptanthus nepalensis*, *Xanthoxylum nepalensis*, *Arundinaria* spp, *Daphne bholua*, *Rosa* sp, *Elaeagnus parvifolia*, *R. lepidotum*, and *Jasminum humile*. The major herbaceous floras in this range were *Artemisia* spp, *Gentiana strobilacea*, *Euphorbia wallichii*, *Stiparoylei* spp, and *Poa* spp.

Himalyan Tahr (*H. jemlahicus*) and Musk Deer (*M. chrysogaster*) were the most common species of local wild ungulates. Danphe and Chilme Munal are distributed abundantly throughout the jungle.

4.4. Altitude preferred by Musk deer

Based on direct sightings and fecal matter/pellets/dung pile, Musk deer preferred around 3800 m to 4000 m altitude (Table 1 and 2). In context of Nepal, altitude where the direct sightings and pellets found was almost tree line. Most of the direct sightings and pellets were found in North East aspect.

Chapter five: Conclusion and Recommendation

5.1 Conclusion

The musk deer sightings and indirect evidences were large in number in different sites of Sagarmatha National Park during a short survey period. We can assume that 52 live sighting is sure for the count while fresh pellets group (266) or dung piles also can be included as the live number of musk deer. However these fresh pellets could be of same 52 live animals and may be individual might have defecated twice a day. Therefore, we can say there are more than 200 live musk deer at least in Sagarmatha National parks in the census forest patches. We can hope adding of numbers by including other potential habitats if we can explore. The number of fawns accompanying each female or family group can provide an indirect estimation the reproductive potentials of musk deer. The potential habitat of musk deer in SNP should be conserved evaluating the presence of musk deer in respected habitat that we observed and also buffer zone areas of such habitat should be taken care.

There are some positive signs for the future of wildlife and musk deer conservation in SNP. There is a high public awareness about wildlife conservation, an appreciation for wildlife and natural resources, and a desire for developing eco-tourism. We speculate such feelings while acquiring information of forest patches and meetings with local people. There is also an absence of organized market hunting for musk deer in this region. However, challenges remain. The future growth and expansion of the human population into the musk deer habitat, the growing awareness of market trends facilitated by new communication links and mass media, and political instability will expose musk deer to increased hunting pressure and negatively impact habitat potentials. A well-managed, carefully handled awareness campaign combined with equitable use of wild resources will be needed to engage local communities with musk deer conservation efforts in SNP. Extensive surveys of musk deer in the surrounding valleys using the protocols suggested in this study will help better understand the population dynamics of the musk deer.

5.2 Recommendations

The musk deer sightings and indirect evidences were large in number in different sites of Sagarmatha National Park during a short survey period. There were 52 live musk deer sighting while fresh pellets group 266 or dung piles were also recorded. Therefore we can say there are more than 300 live musk deer in the Sagarmatha National parks at least on the census forest patches. Some effective measures can be taken into consideration for the further conservation of musk deer and protection of their habitat in SNP:

1. The areas where musk deer were sighted high in number and fresh pellets were found should be kept under close monitoring. Further researches should be focused in those areas.

2. The areas were old pellets were recorded should be studied in order to explore the causes and reasons behind the absence of fresh pellets as well as individual animals. Whether human intervention is need or not in such areas should be assessed.

3. Some areas within SNP and its buffer zone are subjected to habitat degradation and frequent fragmentation; such areas should be afforested with suitable floral species for the musk deer.

4. The potential predator species of musk deer should be identified. If the predator species is high in number and causing immense damage to the musk deer population, then suitable steps need to be taken regarding this matter.

5. The CFG members and general public around the forest areas should be educated further on the conservation of musk deer and their habitat. A well-managed, carefully handled awareness campaign combined with equitable use of wild resources will be needed to engage local communities with musk deer conservation efforts in SNP.

6. Extensive surveys of musk deer in the surrounding valleys using the protocols suggested in this study will help better understand the population dynamics of the musk deer.

7. If GoN passed the bills on wildlife farming and included musk deer species also, locals should be encouraged for farming the species in their area under semi-wild condition. It will help locals and national income generation and research on the species.

8. Training to Park staff and local community people on wildlife monitoring and conservation should be lunched.

9. Regular refresher training programs should be conducted to the local people, FUG, BZCFU groups and yak and sheep herders and also hotel owners.

10. Park office and posts should be equipped with latest communication network to Park headquarters and awareness for conservation and management of wildlife and their habitats.

References for this study

Aryal, A. and Subedi, S. 2011. The conservation and potential habitat of the Himalayan musk deer, *Moschus chrysogaster,* in the protected areas of Nepal. International Journal of Conservation Science, **2**: 127-141.

Aryal, A., Raubenheimer, D., Subedi, S. and Kattel, B. 2010. Spatial habitat overlaps and habitat preference of Musk deer (*Moschus chrysogaster)* in Sagarmatha National park, Nepal. Current research Journal of Biological Sciences, **2**: 217-225.

Barrette, C. 1987. The Comparative Behavior and Ecology of Chevrotain, Musk deer and Morphologically Conservative deer. In: Biology and conservation of the Cervidae (ed. C.M. Wemmer), pp. 200-214. Smithsonian Institution Press, Washington USA.

Bibby, C. J., Burgess, N.D. and Hill, D.A. 1992. Bird Census Techniques. Academic Press, London, New York, Boston etc. pp 1-248.

Boyce, M. S., Vernier, P. R., Nielsen, S. E., & Schmiegelow, F. K. A. (2002). Evaluating resource selection functions. Ecological Modelling, 157: 281-300.

Chalise, M. K. 2008. Nepalka Samrakshit Banyajantu, (Nepal's Protected Wildlife) in Nepali.ShajhaPrakashan, (A Corporate publishing house) Lalitpur Kathmandu Nepal, page 116+12.

Chalise, M. K. 2012. Current status of Musk deer in Api Nampa Conservation Area, Darchula, Nepal (A case study of Ghusa and Khandeswori VDCs of ANCA). Submitted to ANCA office, Darchula Nepal.

Chalise M.K. 2014.Nepalka Kasturii Prajatiharu. Revoscience, Vol. IV, no.III, June p. 22-23.

Chalise M.K. 2016. Nepalka Banyajantu, Bhag 4 (Nepal's Wildlife, Part 4) in Nepali. p. 7+ 241. NEBORS, Lalitpur.

Chalise M.K. and Thagunna, S.S 2014. Status of Musk Deer in Api Nampa Conservation Area, Darchula, Nepal. 19th Wildlife week, Special Issues on Biodiversity Conservation Efforts in Nepal. DNPWC, Kathmandu, Nepal, p. 1-13.

DNPWC, 2004. Langtang National Park. Department of National Park and Wildlife Conservation. Babarmahal, Kathmandu.

Flerov, C.C. 1952. Fauna of the USSR, 1 (2) *Mammals: Musk Deer and Deer*. USSR Academy of Sciences, Moscow (Translated from Russian by Israel Program for scientific Translations). pp. 14-45.

Flower W. H. 1875 : On the structure and affinities of the musk deer (*Moschus chrysogaster*, Linn.) Proceedings of the Zoological Society of London 1875 : 159-190.

Fox, J., Yonzon, P. and Podger, N. 1996. Mapping Conflicts between Biodiversity and Human Needs in Langtang National Park, Nepal. Conservation Biology, 10: 562-569.

Green, M.J.B. 1986. The distribution, status and conservation of the Himalayan musk deer (*Moschus chrysogaster*). Biological Conservation, 35: 347–375.

Green, M. J. B. 1987. Some ecological aspects of a Himalayan population of musk deer. *In* Biology and Management of the Cervidae. *Edited by* C. M. Wemmer. Washington, D. C.: Smithsonian Institution Press. pp. 307-319.

Groves C.P.,Wang Y. and Grubb P. 1995 : The taxonomy of Moschus. Acts Theriolgica Sinica 15 (3): 181-197. (in Chinese with English abstract).

Grubb, P. 2005. Artiodactyla. In D. E. Wilson, & D. M. Reeder (Eds.), Mammal Species of the World: A Taxonomic and Geographic Reference (pp 637-722). Baltimore: The Johns Hopkins University Press.

Homes,V. (1999). *Onthe Scent: Conserving Musk Deer – the Uses of Musk and Europe's Role in its Trade*. TRAFFIC Europe.

Huffman, B. 2004. Himalayan Musk deer. http://www.ultimateungulate.com/artiodactyla/ Moschus chrysogaster. html

Kattle, B. 1992. Ecology of Himalayan musk deer in Sagarmatha National Park, Nepal. Ph.D. thesis, Colorado State University, Fort Collins, Colorado, USA.

Karki, M. B. 2008. Distribution and Population Status of Himalayan Musk Deer (*Moschus chrysogaster* Hodgson 1839). A dissertation submitted, Institute of Science and Technology, Tribhuwan University, Kritipur, Kathmandu Nepal.

Khan, A.A., Qureshi, B.D. and Awan, M.S. 2006. Impact of musk trade on the decline in the Himalayan Musk deer (*Moschus chrysogaster*) population in Neelum Valley. Current Science., **91**: 696-699.

Metz, J. J. 1990. Conservation Practices at an Upper-Elevation Village of West Nepal. Mountain Research Development, 10: 7-15.

Mishra, C., Wieren, S. E. V., Ketner, V., Heitkönig, I. M. A., & Prins, H. H. T. 2004. Competition between domestic livestock and wild bharal *Pseudois nayaur* in the Indian trans-Himalaya. Journal of Applied Ecology, 41: 344-354.

Namgail, T., Fox, J. L., & Bhatnagar, Y. V. 2007. Habitat shift and time budget of the Tibetan argali: the influence of livestock grazing. Ecological Research, 22: 25-31.

Negi, H.R. 1996. Usnealongissima- the winter staple food of Musk deer.A case study of Kanchula-khark Musk deer breeding center in Garhwal Himalayas. Tiger paper Vol. 23(1):30-32

Nowak, R. M. [editor]. 1991. Walker's Mammals of the World (Fifth Edition). Baltimore: The Johns Hopkins University Press.

Pandey, M. and Chalise, M. K 2011.Status, Threats and Conservation of Himalayan Musk deer (*Moschus chrysogaster*) in Langtang valley, Langtang National Park (LNP), Nepal. Online Journal.

Qureshi, B.D., Awan, M.S., Khan, A.A., Dar, N.I. and Dar, M.E. 2004. Distribution of himalayan musk deer (*Moschus chrysogaster*) in Neelum Valley, District Muzaffarabad, Azad Kashmir. Journal of biological. Science., **4**: 258–261.

Rajchal, R., 2006. Population Status, Distribution, Management, Threats and Mitigation Measures of Himalayan Musk Deer (*Moschus chrysogaster*) in Sagarmatha National Park. A Report submitted to DNPWC/TRPAP, Babarmahal, Kathmandu, Nepal. Institute of Forestry, Pokhara, Nepal.

Roberts, T.J., 1997. The mammals of Pakistan. Oxford University Press. Karachi, pp. 525.

Schaller, G.B. 1977. Mountain monarchs: Wild sheep and goats of the Himalayas. University of Chicago Press, Chicago USA, pp. 425.

Sheng Helin, Noriyuki Ohtaishi, and Lu Houji. 1999. The Mammalian of China. Beijing: China Forestry Publishing House.

Shrestha, M. 1989. Musk deer *Moscus chrysogaster*: musk extraction from live deer. Journal of the Bombay Natural History Society, 86:438-440.

Shrestha, T.K. 1997. Mammals of Nepal. B. Shrestha. Kathmandu. Pp.720.

Shrestha, M.N. 1998. Animal welfare in the musk deer. Applied Animal Behavior Science, 59(1): 245-250.

Shrestha, T.K. 2003. Wildlife of Nepal. B. Shrestha, Kathmandu, Nepal. 720 p.

SNP 2004. Monitoring of the Himalayan Musk Deer in Sagarmatha National Park. Department of National Parks and Wildlife Conservation/ Sagarmatha National Park, Namche, Solukhumbu, Nepal.

Trivers R.L. 1972. Parental investment and sexual selection. In:Sexual selection and the descent of man (ed. B. Campbell), Aldine, Chicago, USA. pp. 136-179.

Whitehead, K. G. 1993. The Whitehead Encyclopedia of Deer. Stillwater, MN: Voyageur Press, Inc.

Wilson, D. E., and D. M. Reeder [editors]. 1993. Mammal Species of the World (2nd ed). Washington, Smithsonian Inst Press. Online at http://nmnhwww.si.edu/msw/

Zhiwotschenko, V. 1990. Musk Deer. *In* Grzimek's Encyclopedia of Mammals. *Edited by* S. P. Parker. New York: McGraw-Hill. Volume 5, pp. 133-136.

Zhou, Y., Meng, X., Feng, J., Yang, Q., Feng, Z., Xia, L. and Barots, L. 2004. Review of the distributin, status and conservation of musk deer in China, Folia Zool., 53: 129-140.

Annex

1: List of contact person during the study

Name	**Designation**	**Address**
Jay Ram Neupane	Ranger	SNP
Dilli Kumar Rai	Hotel owner (Trekkers Lodge)	Tyangboche
Dmi Kshiri Sherpa	Hotel owner (Zambala Lodge)	Phungi Thanga
Futasi Sherpa	Hotel owner (Trekker Holiday Inn Lodge)	Pangboche
Lagan Rai	Sonam Lodge	Somare
Mingma Lama	Hotel owner (Ever Green Lodge)	
Nim Dorje Sherpa	Hotel owner (Everest Lodge & Restaurant)	Debuche
Nuru Galgen Sherpa	Hotel owner (Everest Lodge)	Phorsche
Palden Sherpa	Hotel owner (Trekkers Lodge)	Thangnak
Pemba Sherpa	Hotel owner (Buddha Lodge)	
Pemba Yangi Sherpa	Hotel owner (Dole Resort)	Dole
Phu Tenzing Sherpa	Hotel Owner (River Resort)	Phorsche Thanga
Sonam Sherpa	Hotel owner (Yeti Mountain Home Resort)	Manjo

2: List of participant in this study

Name	**Designation**
Bharat Karki	Game Scout
Lak Bahadur Rai	Game Scout
Bishowa Nath Oli	Senior Game Scout
Ganga Dhakal Khanal	Senior Game Scout
Mishra Kaji Tamang	Senior Game Scout
Parbat Rai	Senior Game Scout
Pesal Kumar Magar	Senior Game Scout

Sanjog Kumar Yadav	Senior Game Scout
Bikalpa Acharya	Game Scout
Jiten Rai	Game Scout
Lalit Karki	Game Scout
Matrika Khanal	Game Scout
Milan Rijal	Game Scout
Narayan Acharya	Game Scout
Nirman Kumar Pokhrel	Game Scout
Ramsaran Yadav	Game Scout
Sanjay Yadav	Game Scout
Santosh Ramtel	Game Scout
Saroj Dhakal	Game Scout
Suraj Basnet	

Photo plates from the field Activities

Group meeting of team with Park staff along with Warden, Mr. Promod Bhattarai

Musk deer in Bhojpatra forest

Fir/Pine species

Musk deer habitat with National Bird- Lophure sp. (Danfe)

Musk deer habitat

Musk deer habitat inaccessible for general public.

Musk deer habitat near Thamserku

Bhojpatra forest is found favored by Musk deer.

Bhojpatra dominated forest with other species.

Carnivores' droppings in Musk deer habitat.

Musk deer in mixed forest area.